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Dynamic decollement formation in high-resolution distinct-element models of accretionary wedges

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The understanding of accretionary wedge evolution remains a widely debated problem. Analogue and numerical models where sediments are scraped off and accreted in front of a moving plow have been used to investigate the dynamic development of geological structures at these sites of continental growth. In most analogue shortening experiments a predefined weak layer (using microbeads) is embedded in a stronger material (mostly made of sand). The microbeads imply an initial inhomogeneity that forces a localised deformation along this layer that is regarded as the subduction decollement. Most numerical experiments also use this set-up in order to reproduce the analogue sandbox models.

However, we present numerical simulations with a model set-up that creates the decollement dynamically during progressive convergence. This approach (1) allows to mimic fault zone weakening and (2) omits the implementation of a predefined initial inhomogeneity. Thus, the subduction decollement is created by the accretion process itself while an initially homogeneous sediment body resting on top of the oceanic plate moves towards the subduction zone.

We (1) test the effect of a dynamically evolving decollement in shortening experiments and compare it (2) to standard models with a static predefined weak layer and (3) to models without any initial inhomogeneity. Simulations are performed with a distinct element method (DEM) that describes the physical interaction of discrete particles and the consequent displacement field during deformation. For our models we use the distinct element software PFC2D. Within our high resolution 2D models single particles are connected to each other by breakable bonds to simulate rather a cemented rock than loose sediments. Once bonds are broken during deformation displacement

of the particles is solely controlled by their stiffness and friction.

In the first model containing no initial weak layer all particles are bonded and have the same microproperties (corresponding to analogue models using a homogeneous sand pile). In the second model we implement an initial inhomogeneity by introducing a layer of unbonded low-friction particles (comparable to the use of microbeads). In the third experiment we simulate a dynamically generated decollement. This is achieved by using an initially bonded low-friction layer where weakening due to lower friction does not apply until the connecting bonds are broken.

Comparing the outcomes of the shortening experiments that result from the three different model set-ups there are fundamental variations in the progressively evolving stress patterns. These differences have implications on the topography of the accretionary wedge, the localisation of deformation, and the resulting fault pattern (orientation and spacing). Reviewing the results we suggest that numerical models with a set-up allowing the development of dynamically evolving decollements should be considered as a realistic approach to simulate accretionary processes.